Linear and Nonlinear Rossby Waves in Basins both with and without a Thin Meridional Barrier

by

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B.S., McGill University (1997)

Submitted to the Joint Program in Physical Oceanography
in partial fulfillment of the requirements for the degree of

Master of Science

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
and the
WOODS HOLE OCEANOGRAPHIC INSTITUTION

February 2002

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Abstract

The linear and nonlinear Rossby wave solutions are examined in homogeneous square basins on the β-plane both with and without a thin meridional barrier. In the presence of the meridional barrier the basin is almost partitioned into two; only two small gaps of equal width, d, to the north and south of the barrier allow communication between the eastern and western sub-basins.

Solutions are forced by a steady periodic wind forcing applied over a meridional strip near the eastern side. Bottom friction is present to allow the solutions to reach equilibrium. The linear solution for the basin containing the barrier is determined analytically and the nonlinear solutions for both basins are found numerically.

In the linear solution with the barrier present, particular attention was paid to the resonant solutions. We examined the effects of varying the symmetry of the forcing about the mid-latitude, the frequency of the periodic forcing and the strength of the bottom friction. For each solution we focus on how the no net circulation condition, which is central to any solution in a barrier basin, is satisfied.

The nonlinear solutions were studied for both basin configurations. In each case the transition from the weakly nonlinear solution to the turbulent solution was examined, as the forcing frequency and forcing strength were varied. Only integer multiples of the forcing frequency are present in the weakly nonlinear solutions. The turbulent solutions were accompanied by the appearance of many other frequencies whose exact origins are unknown, but are probably the result of instabilities.

A hysteresis was found for the turbulent solutions of both the barrier-free and barrier basins.

In the weakly nonlinear solutions of the barrier basin it was predicted and confirmed that there is never a steady net flow from sub-basin to sub-basin. It was also shown that with a symmetric forcing all modes oscillating with an odd multiple of the forcing frequency are symmetric and all modes oscillating with even multiples of the forcing frequency are antisymmetric.

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Acknowledgments

I would like to thank my advisor, Joe Pedlosky, for introducing me to the the problem of studying Rossby modes for various basin configurations and for helping me publish my pregenerals research (presented in chapter 3 of this thesis) in Il Nuovo Cimento. I am especially grateful for the way Joe has made himself readily available for discussions and for his promptness in returning my work and providing feedback.

I would also like to thank my committee members Mike Spall, Joe LaCasce, Nelson Hogg, and Glenn Flierl. In particular, I thank Mike Spall for giving me his modified version of MICOM when I began my research.

Special thanks are due to thank my classmate Pablo Zurita who has been a good friend and has helped me immensely in the last few years. Through numerous discussions we have had, I have learnt a great deal me much about computers and numerical computation. This not only helped me to get MICOM running, but has provided me with skills that will be very helpful in the future. I am also grateful to Pablo for allowing me to run MICOM and store my results on his computer.

I am indebted to Brian Arbic who directed the computer Huron my way when he went to Princeton. Huron has been a great benefit to me this last year. I would alsolike to thank Richard Wardle, Francis Poulin, and Samar Khatiwala for interesting discussions regarding this thesis.

Last, but not least, I would like to thank my parents, sister, and Adrian for all their encouragement.

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